completely saturated at 10° C., it expands to 1.0122 cubic meters. (See problem 18.) The difference between these two cases is seen to be very small.

Special case.—The student should solve the following: What quantity of dry air in cubic meters under 760 millimeters pressure, when mixt with the quantity of vapor necessary to saturate 1 cubic meter of space, will expand so as to occupy exactly 1 cubic meter and be saturated? Ans. $1-e/b$ cubic meter.

Problem 22.—What is the relative humidity of the mixture considered in problem 21, and what is the vapor pressure in the special case where a cubic meter of saturated vapor is taken?

Solution.—The mixture contains only the weight of vapor necessary to saturate 1 cubic meter of space, which, by equation (2) problem 13, is

$$\frac{1293.05\times 0.622\, e}{(1+at)\,760} \text{ grams of vapor}\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

But by problem 21, the cubic meters of air and vapor have expanded to $(B+e)/b$ cubic meters, and this increased volume, if saturated, will contain

$$\frac{1293.05\times 0.622\, e\times(B+e)}{(1+at)\,760\, b} \text{ grams of vapor}\ldots\ldots\ldots(2)$$

Since relative humidity, exprest as a percentage, is 100 multiplied by the ratio of the quantity of vapor actually present, as given by (1), to the quantity of vapor the expanded volume could contain if saturated, given by (2), we have

$$\text{Relative humidity} = 100\, b/(B+e) \text{ per cent.}$$

Special case.—In a mixture under 760 millimeters pressure, of 1 cubic meter of dry air at 760 millimeters, and 1 cubic meter of saturated vapor, both at 10° C., since $e=9.14$ millimeters, we have

$$\text{Relative humidity} = 100\times\frac{760}{760+9.14} = 98.8 \text{ per cent.}$$

The actual vapor pressure divided by the saturation vapor pressure is the relative humidity; if this ratio is multiplied by 100, we get the relative humidity exprest as a percentage. If the relative humidity of any mixture is 50 per cent, the vapor pressure is 50/100 of saturation; it is therefore $e\times 50/100$. If the relative humidity, as above, is $100\,b/(B+e)$ per cent, the vapor pressure becomes

$$\frac{e}{100}\times\frac{100\,b}{B+e}=\frac{e\,b}{B+e}$$

In the case given, where $e=9.14$ mm., the vapor pressure is

$$\frac{9.14\times 760}{760+9.14}=9.03 \text{ mm.}$$

Problem 23.—What volume will a cubic centimeter of water at temperature 4° C. (when it has its maximum density) occupy in the state of vapor at the temperature of 100° C.?

Solution.—This is a very simple application of the formula of problem 13. A cubic meter of saturated vapor at 100° C. weighs

$$\frac{0.622\times 1293.05}{1+(0.00367\times 100)}\times\frac{760}{760}\text{grams}$$

since at 100° C. the vapor pressure is 1 atmosphere, or 760 millimeters.

This reduces to 588 grams. Then if 1 cubic meter weighs 588 grams, 1 gram at 100° will occupy 1/588 cubic meter or 0.001698 cubic meter, which is 1698 cubic centimeters. One gram of water at its maximum density at 4° C. occupies 1 cubic centimeter; so 1 cubic centimeter of water at 4° C. occupies 1698 cubic centimeters when it becomes vapor at 100°. See Deschanel, page 363, part 284.

Problem 24.—To find the vapor tension, the temperature of the dew-point, the weight of the vapor and the dry air, respectively, and the relative humidity when we know the temperatures of the dry-bulb and wet-bulb thermometers.

This is best done by the use of any psychrometric table, e. g., Marvin's Tables, published by the Weather Bureau. Many examples should be worked out by these tables in order to attain proficiency and secure familiarity. The physical principles on which these tables are based are explained at pages 380–391 of Professor Ferrel's Recent Advances in Meteorology, published as Appendix 71 to the Annual Report of the Chief Signal Officer, 1885. They are also given in Section D of the Treatise on Meteorological Apparatus and Methods, published as Appendix 46 to the Annual Report of the Chief Signal Officer, 1887.

Problem 25.—How much will the air be warmed by the latent heat liberated in the formation of a certain amount of frost?

Solution.—On February 26, 1905, Mr. Seeley melted the frost and found its equivalent to be 0.018 inch in depth of water; 0.018 inch is 0.457 millimeter. Since 1 kilogram (1000 grams) on a square meter of surface is equal to 1 millimeter of water at its maximum density, i. e., at 4° C., then to obtain 0.457 millimeters of precipitation would require 457 grams on a square meter, or the 0.018 inch is equal to 457 grams per square meter.

The amount of heat liberated by the condensation of 1 gram of vapor to water at 0° C. is in round numbers 600 calories, and the freezing of 1 gram of water liberates 80 calories additional, or a total of 680 calories. Hence, 457 grams will liberate 680 × 457 or 310 760 calories.

A cubic meter of air at 0° C. and 760 millimeters weighs 1293.05 grams. The specific heat of air is 0.238; to warm 1293.05 grams of air 1° C. will require 1293 × 0.238 calories or 307.734 calories. As the precipitation liberated 310 760 calories, this is sufficient to warm up 310 760 ÷ 307.734 or 1009.8 cubic meters of air 1° C. This was solved in English measures in the MONTHLY WEATHER REVIEW, April, 1905, page 155, but the following is more accurate:

A column 1009.8 meters high above a square meter of ground becomes in English measures a column 3313.6 feet high above a square foot of ground. Hence, the heat liberated in this column will warm up its 3313.6 cubic feet of air by 1° C. or 1.8° F.; or 331 cubic feet by 18° F., or 596 cubic feet by 10° F.

[The 525 cubic feet given in the April, 1905, REVIEW undoubtedly arose from using 535.9 (more properly 536.6) as the latent heat of vaporization at 0° C. This is really the latent heat of vaporization at the boiling point, and the proper figure for the freezing point is 596.7, to which must be added 80 as the latent heat for melting ice at 0° C., making a total of 676.7. See Watson, Text Book of Physics, fourth edition, page 249. The Editor may be responsible for the error.—EDITOR.]

PROBLEMS IN MIXTURES OF AIR AND VAPOR.

[The general problems of mixtures of vapor and air are solved algebraically by the EDITOR in the following lines, to which Mr. von Herrmann has added notes and numerical examples.]

1. Let n volumes of dry air at pressure p_a, relative humidity 0, and temperature t, mix with n' volumes of aqueous vapor at pressure p_v, relative humidity r, and temperature t, forming within a rigid inclosure $n+n'$ volumes of mixture at pressure p_a' for dry air, and p_v' for vapor, and total pressure p', relative humidity r', and temperature t.

Let e be the saturation tension of the vapor for temperature t. For accurate work both p and e must be exprest in standard units, e. g., the height of a column of mercury under standard temperature and gravity. The law of Boyle states that as long as the temperature remains the same, the product of the volume (V) of a given mass of any gas, into the pressure (P) is equal to the product of its volume (V') under any other pressure (P') into that pressure, or

$$P\ V = P'\ V' = \text{constant}.$$

The law applies approximately to aqueous vapor, and to each gas in a mixture independent of the presence of other gases.

Thus we obtain the following relations:

Partial pressures.—The total volume $(n+n')$ multiplied by the partial pressure for the dry air, p_a' must equal the original volume of dry air n, multiplied by the pressure p_a, or

$$(n+n')\,p_a' = n\,p_a \quad \ldots\ldots (1)$$

Also, the total volume $(n+n')$ multiplied by the partial pressure of the vapor p_v', must equal the original volume of the vapor n' multiplied by its pressure p_v, giving

$$(n+n')\,p_v' = n'\,p_v \quad \ldots\ldots (2)$$

Relative humidity.—Relative humidity is the ratio of the vapor tension present to the saturation tension of the vapor for temperature t, or in the case of aqueous vapor at tension p_v (saturation tension being e),

$$r = \frac{p_v}{e} \quad \ldots\ldots (3)$$

In $(n+n')$ volumes of the mixture, the vapor tension is p_v', the tension of saturation is e, therefore

$$r' = \frac{p_v'}{e} \quad \ldots\ldots (4)$$

From (2), $p_v' = n'p_v/(n+n')$, which substituted in (4) gives

$$r' = \frac{n'}{n+n'} \times \frac{p_v}{e} \text{ or } r' = \frac{n'}{n+n'}\,r \quad \ldots\ldots (5)$$

Total pressure.—$\ldots\ldots p' = p_a' + p_v' \quad \ldots\ldots (6)$

Total mass.—$\ldots\ldots (n+n')\,p' = n\,p_a + n'\,p_v \quad \ldots\ldots (7)$

2. Let the rigid inclosure be opened; the atmospheric pressure b becomes the inclosure that acts on the mixture, allowing it to form n'' volumes of mixture, at total pressure b, relative humidity r'' and temperature t. The new relations will be:

Partial pressures.—For air, since the original volume n multiplied by its pressure p_a must equal the new volume n'' multiplied by its partial pressure p_a'',

$$n\,p_a = n''\,p_a'' \text{ or } p_a'' = \left(\frac{n}{n''}\right)p_a \quad \ldots\ldots (8)$$

Similarly for vapor

$$n'\,p_v = n''\,p_v'' \text{ or } p_v'' = \left(\frac{n'}{n''}\right)p_v \quad \ldots\ldots (9)$$

Relative humidity.—Substituting the value of p_v'' from (9)

$$r'' = \frac{p_v''}{e} = \frac{n'}{n''} \times \frac{p_v}{e} = \frac{n'}{n''}\,r \quad \ldots\ldots (10)$$

Total mass.

$$n''\,b = (n+n')\,\frac{n\,p_a + n'\,p_v}{n+n'} = n\,p_a + n'\,p_v \quad \ldots\ldots (11)$$

This must evidently be true by (7) since the mass has not been changed.

Total pressure.

$$b = p_a'' + p_v'' = \frac{n}{n''}\,p_a + \frac{n'}{n''}\,p_v \quad \ldots\ldots (12)$$

Total volume.

$$n'' = \frac{n\,p_a}{b} + \frac{n'\,p_v}{b} \quad \ldots\ldots (13)$$

$$\frac{n''}{n} = \frac{p_a}{b} + \frac{n'\,p_v}{n\,b} \quad \ldots\ldots (14)$$

3. Let 1 volume of dry air be mixt with n' volumes of saturated vapor, and apply atmospheric pressure b; the above equations become as follows:

Volume of dry air, $n=1$; volume of saturated vapor, n': tension of saturated vapor $p_v = e$; relative humidity of saturated vapor is always 1; $r=1$.

By (11) $n''\,b = p_a + n'\,e \quad \ldots\ldots (15)$

$$n'' = p_a/b + n'\,e/b = \frac{p_a}{b}\left(1 + \frac{n'\,e}{p_a}\right) \quad \ldots\ldots (16)$$

By (9) $p_v'' = \left(\frac{n'}{n''}\right)p_v = \left(\frac{n'}{n''}\right)e \quad \ldots\ldots (17)$

By (10) $r'' = \frac{p_v''}{e} = \frac{n'}{n''}\,r = \frac{n'}{n''} \quad \ldots\ldots (18)$

(*a*) *Numerical example.*—1 cubic meter of dry air under 600 millimeters pressure is mixt with $\frac{1}{2}$ cubic meter of saturated vapor, both at temperature 10°; let atmospheric pressure (760 mm.) be applied; find volume n'', relative humidity r'', and vapor pressure p_v''.

$p_a = 600$ mm; $n' = 0.5$; $e = 9.14$ mm.; $b = 760$ mm.

$n'' = \frac{600}{760}\left(1 + \frac{0.5 \times 9.14}{600}\right)$ which is 0.795 cubic meter.

$r'' = \frac{0.5}{0.795} = 0.629$ or 62.9 per cent.

$p_v'' = 0.629 \times 9.14 = 5.75$ mm.

(*b*) If the original cubic meter of air had been under a pressure of 760 mm., the answer would have been $n'' = 1.006$ cubic meters; $r'' = 0.497$ (49.7 per cent); $p_v'' = 4.54$ mm. Check computation for relative humidity: 1 cubic meter of saturated air at 760 mm. and 10° C. contains 9.34 grams of vapor; the volume 1.006 cubic meters, if saturated would contain $9.34 \times 1.006 = 9.396$ grams. The amount of vapor added was $\frac{1}{2}$ cubic meter or $\frac{1}{2}$ (9.34) = 4.67 grams, hence relative humidity is 4.67/9.396 = 0.497.

(*c*) *Numerical example.*—1 cubic meter of dry air under 760 mm. pressure is mixt with 1.012173 cubic meters of saturated vapor, both at 10° C.; atmospheric pressure 760 mm. is applied, find the volume, relative humidity, and vapor tension.

$$n'' = \frac{760}{760}\left(1 + \frac{1.012173 \times 9.14}{760}\right) = 1.012173\ \text{m}^3.$$

$$r'' = 1.012173/1.012173 = 1, \text{ or } 100 \text{ per cent.}$$

$$p_v'' = 9.14 \times 1 = 9.14\ \text{mm}.$$

The student should interpret this result. Evidently we have added to the original cubic meter of dry air just the quantity of vapor necessary to saturate the whole mass of air at its increased volume, in which case the relative humidity becomes 100 per cent, or the vapor tension is the same as the vapor tension for saturation.

(*d*) Interpret the result when more than 1.012173 cubic meters of vapor are added to 1 cubic meter of dry air both at the same pressure and temperature. Evidently more vapor has been added than is capable, under the conditions, of existing as vapor, and the excess must be condensed to water.

(*e*) If, in the first numerical example, the cubic meter of air is under a pressure of 375.43 mm., interpret the result.

Under 760 mm. the volume of air reduces to such volume that the quantity of vapor supplied just saturates it. Therefore the pressure of the original cubic meter of air can not be assumed less than 375.43 mm. at 10° C.

4. Let 1 volume of dry air, pressure p_a, be mixt with 1 volume of saturated vapor, pressure p_v, under the total atmospheric pressure b; we have the following relations:

$$n = 1;\ n' = 1;\ p_v = e;\ r = 1 \quad \ldots\ldots (19)$$

$$n'' = \frac{p_a}{b}\left(1 + \frac{e}{p_a}\right) = \frac{p_a + e}{b} \quad \ldots\ldots (20)$$

$$p_v'' = \frac{1}{n''}\,e = \frac{b}{p_a + e} \times e \quad \ldots\ldots (21)$$

$$r'' = \frac{p_v''}{e} = \frac{1}{n''} = \frac{b}{p_a + e} \quad \ldots\ldots (22)$$

5. Let p_a be the same as the total atmospheric pressure b, then equations (20) and (22) become

$$n'' = 1 + e/b;\ \text{and}\ r'' = b/(b+e) \ldots\ldots (23)$$

Numerical example.—1 cubic meter of dry air under 755 mm. pressure is mixt with 1 cubic meter of saturated vapor, both at 10° C.; find the volume, humidity, etc., under the total pressure of 760 mm. $n = 1$; $n' = 1$; $p_v = e = 9.14$; $p_a = 755$; $b = 760$

$$n'' = \frac{755 + 9.14}{760} = 1.005 \text{ cubic meter.}$$

$$r'' = 1/1.005 = 0.9945 \text{ or } 99.45 \text{ per cent.}$$

NOTE.—If in this case we had assumed the original dry air pressure to be less than 750.86 mm., the resulting n'' would have been less and the r'' greater than 1. This means that some of the vapor must condense to water on or within the inclosure, so that the total mass of vapor and air is diminished, a condition not contemplated or provided for in the original problem.

Numerical example.—Find the volume and relative humidity of a mixture of 1 cubic meter of dry air under 760 mm., and 1 cubic meter of saturated vapor, both at 10° C. ($e = 9.14$); this mixture also to be under atmospheric pressure ($b = 760$.)

$$n'' = 1 + 9.14/760 = 1.01203 \text{ cubic meters.}$$

$$r'' = 760/769.14 = 0.988 \text{ or } 98.8 \text{ per cent.}$$

$$p_v'' = 0.988 \times 9.14 = 9.03 \text{ mm.}$$

If the temperature be 30° C., $e = 32.51$, $n'' = 1.04276$; relative humidity 95.9 per cent.

If the temperature be 0° C., $e = 4.60$, $n'' = 1.00605$; relative humidity 99.4 per cent,

The lower the temperature the closer the final volume approximates 1 and the relative humidity 100 per cent.

6. If we consider only 1 volume of the mixture, at the total pressure b, the general equations of articles 1 and 2 hold good for the mixture, but we must put $n'' = 1$.

7. What volume, n, of dry air, at pressure p_a and relative humidity 0, and what volume, n', of vapor, at tension p_v and relative humidity r, at the temperature t, for which e is the saturation tension, must be mixt in order to obtain 1 volume of saturated mixture at the pressure b?

For the saturated mixture $n'' = 1$, $r'' = 1$. Therefore the general equations of article 2 become

$$\text{By (10)}\ r'' = \frac{n'}{n''} r = n' r = p_v''/e = n' p_v/e = 1 \ldots\ldots (24)$$

$$\text{Therefore}\ p_v'' = n' p_v = e \ldots\ldots (25)$$

$$\text{and}\ n' = \frac{e}{p_v} \ldots\ldots (26)$$

Since the dry air is at the pressure $(b - e)$ in the saturated mixture, therefore by (8)

$$p_a'' = \frac{n}{n''} p_a = n p_a = (b - e) \ldots\ldots (27)$$

$$\text{Equation (13)},\ n'' = \frac{n p_a}{b} + \frac{n' p_v}{b},\ \text{becomes}\ 1 = \frac{n p_a}{b} + \frac{n' p_v}{b} \ldots (28)$$

$$n = \frac{b}{p_a} - \frac{n' p_v}{p_a} \ldots\ldots (29)$$

In this substitute for n' its value ($n' = e/p_v$) and we obtain:

$$n = \frac{b}{p_a} - \frac{e}{p_a} = \frac{(b - e)}{p_a} \ldots\ldots (30)$$

Since p_a, p_v, r and b are known, the values of n and n' are found from the equations

$$n' = e/p_v \ldots\ldots (31)$$

and

$$n = (b - e)/p_a \ldots\ldots (32)$$

Numerical example.—An unknown volume (n) of dry air at 760 millimeters is mixt with 1 volume of saturated vapor, both at 10° C., and the final mixture is found to consist of 1 cubic meter of saturated air at 760 millimeters. What was the original volume (n) of dry air?

$$n'' = 1;\ n' = 1;\ p_a = 760;\ p_v = e = 9.14 \text{ mm};\ b = 760$$

$$\text{By (28)}\ n'' = \frac{n p_a + n' p_v}{b};\ \text{or}\ 1 = \frac{n b + e}{b}.$$

$$\text{Therefore, } n = 1 - e/b \ldots\ldots (33)$$

That is, $n = 1 - 9.14/760$ or 0.98797 cubic meters.

If $t = -20°$ C. n is 0.99893
$t = -10°$ C. n is 0.99737
$t = 0°$ C. n is 0.99395
$t = 10°$ C. n is 0.98797
$t = 30°$ C. n is 0.95722

The student should interpret the result when the temperature is 100° C. At 100° C. the vapor pressure for saturation is 760 millimeters, and hence a cubic meter of vapor at that temperature can contain no air when $b = 760$ mm.

Numerical example.—What volume of dry air at 760 millimeters, and what volume of vapor at a tension 4.57 millimeters (i. e., R. H. 50 per cent), both at temperature 10° C., must be mixt in order to obtain one volume of saturated mixture?

Answer.—$n' = 9.14/4.57 = 2$ cubic meters of vapor;
$n = (760 - 9.14)/760 = 0.98797$ cubic meter of dry air.

8. Let n volumes of dry air at pressure p_a and n' volumes of saturated vapor ($p_v = e$) be mixt to make 1 volume of saturated mixture at the pressure b, then by article 7, equations (31) and (32),

$$n' = e/e = 1 \text{ volume of vapor at tension } p_v = e \ldots\ldots (34)$$

$$n = (b - e)/p_a \text{ volumes of dry air at pressure } p_a \ldots\ldots (35)$$

Hence, for the total mixture equation (11) becomes

$$1\,b = n p_a + n' e = \frac{b - e}{p_a} p_a + 1\,e \ldots\ldots (36)$$

and the two terms reduce to the identity $b = b$.

Numerical examples.—(*a*) Let n volumes of dry air under 600 millimeters at 10° C. be mixt with n' volumes of saturated vapor at 10° C. ($p_v = e = 9.14$ millimeters) to make 1 volume of saturated mixture under 760 millimeters; then

$n' = e/e = 9.14/9.14 = 1$ volume of vapor.
$n = (760 - 9.14)/600 = 1.25143$ volumes of dry air.

Air at	760	millimeters,	required volume	0.98797
"	600	"	"	1.25143
"	500	"	"	1.50175
"	400	"	"	1.87715
"	300	"	"	2.5029
"	200	"	"	3.7543
"	100	"	"	7.5086

(*b*) Let n volumes of dry air under 600 millimeters at 10° C. be mixt with n' volumes of vapor under tension of 4.57 millimeters (i. e., R. H. 0.5, or 50 per cent) to make 1 volume of a saturated mixture under 760 millimeters; then

$n' = 9.14/4.57 = 2$ volumes of vapor.
$n = (760 - 9.14)/600 = 1.25143$ volumes of air,

twice the volume of vapor but the same volume of air as in the example just preceding.

---

9. Let n volumes of dry air be mixt with n' volumes of moist air, having the relative humidity r', both being at the same temperature t and pressure of 760 millimeters. Some of the vapor in n' will diffuse into the dry air of n, and some of the dry air will pass from n over to n', until eventually each gas comes into static equilibrium by itself, independently of the other. According to Dalton's Law, the following elations will hold good in the mixture:

$$n'' = n + n' \quad \text{(37)}$$

$$r'' = \frac{n'}{n + n'} r' = \frac{n'}{n''} r' \quad \text{(38)}$$

$$p_v'' = \frac{n'}{n + n'} r' e = r'' e \quad \text{(39)}$$

$$p_a'' + p_v'' = 760 \quad \text{(40)}$$

$$p_a'' = 760 - p_v'' \quad \text{(41)}$$

10. Let n' volumes of air having the relative humidity r' be mixt with n'' volumes of air having the relative humidity r'', both being at the same temperature t and pressure 760 millimeters. If the total pressure continues the same, then the new volume and relative humidity are given by the following equations:

$$n''' = n' + n'' \quad \text{(42)}$$

$$r''' = \frac{n' r' + n'' r''}{n' + n''} \quad \text{(43)}$$

$$p_v''' = r''' e \quad \text{(44)}$$

$$b = p''' = p_a''' + p_v''' = 760 \quad \text{(45)}$$

$$p_a''' = 760 - p_v''' \quad \text{(46)}$$

Numerical examples.—1. If 1 cubic meter of dry air be mixt with 5 cubic meters of air having a relative humidity of 100 per cent, the mixture will consist of 6 cubic meters of moist air having a relative humidity of 83.33 per cent.

2. If 3 volumes of dry air be mixt with 5 volumes of air having a relative humidity of 50 per cent, the mixture will consist of 8 volumes of moist air having a relative humidity of 31.25 per cent.

3. If 3 volumes of air, relative humidity 25 per cent, be mixt with 5 volumes of air, relative humidity 75 per cent, the mixture will consist of 8 volumes of air having a relative humidity of 56.25 per cent.

11. Let n' volumes of air having relative humidity r' and total pressure p' be mixt with n'' volumes of air having relative humidity r'' and total pressure p''; let both have the same temperature t, and let the combined volumes be brought under pressure 760 millimeters and kept at the same temperature. The following equations will give the new volume and humidity:

$$p' = p_a' + p_v' \quad \text{(47)}$$

$$p_v' = r' e \quad \text{(48)}$$

$$p_a' = p' - r' e \quad \text{(49)}$$

$$p'' = p_a'' + p_v'' \quad \text{(50)}$$

$$p_v'' = r'' e \quad \text{(51)}$$

$$p_a'' = p'' - r'' e \quad \text{(52)}$$

$$n''' = \frac{n' p' + n'' p''}{760} \quad \text{(53)}$$

$$r''' = \frac{n' r' + n'' r''}{n'''} \quad \text{(54)}$$

$$p_v''' = r''' e \quad \text{(55)}$$

$$p_a''' = \frac{n' p_a' + n'' p_a''}{n'''} \quad \text{(56)}$$

$$760 = p_a''' + p_v''' \quad \text{(57)}$$

Numerical example.—If 2 volumes of air, relative humidity 50 per cent, under a pressure of 380 millimeters, be mixt with 5 volumes of air, relative humidity 25 per cent, under 500 millimeters pressure, the mixture under atmospheric pressure will consist of 4.29 volumes of moist air with a relative humidity of 52.45 per cent, under 760 millimeters.

THE GROWTH OF FOG IN UNSATURATED AIR.

By FRANK W. PROCTOR. Dated Fairhaven, Mass., November 8, 1906.

During the summers of 1901 and 1902 the writer made terdaily observations of temperature, moisture, barometric pressure, wind direction and velocity, and the occurrence of fog at all hours, except during sleep, for the purpose of studying the origin of the summer fogs that are tolerably frequent on the south shore of Massachusetts, and that are seemingly capricious in their occurrence and endurance. Those observations, so far as they bore on the locus and the proximate cause of formation, and on the manner of advent, of the summer fogs of sufficient density to be called "fog" in the ordinary sense of the term, are discust in the MONTHLY WEATHER REVIEW for October, 1903.[1]

The observations (whose details will not be repeated here), also showed that over Buzzards Bay there existed almost continuously a haze which was deemed to be an aqueous haze, because it could usually be seen when the wind blew from the sea, because it graded so insensibly into the fogs ordinarily so-called that it was impossible to distinguish a thick haze from a light fog, and because the air was so completely cleared of the haze by anticyclones. This haze was observed with a wind from the south, and a relative humidity as low as 52 per cent determined with a sling psychrometer; and in the paper mentioned it was suggested that "the persistent aqueous haze over the bay with winds from seaward, seems to indicate not only that the saturation temperature is different for different kinds of nuclei, but also that under ordinary conditions the variety of suitable nuclei is large enough to make condensation a gradual process rather than a catastrophe at a certain critical vapor pressure".

The following summer a new series of observations was begun for the purpose of trying to correlate the growth of this haze with other weather conditions and changes. But it was found at the outset that as soon as the air was cleared of visible particles by a passing anticyclone, they formed again with astonishing rapidity under all conditions of weather by day and by night; and the observations were thereupon discontinued, with the only further result that it was seen that the haze, like other forms of fog, has a diurnal period, being denser at night when the temperature is lower.

The purpose of this article is to consider whether current theory and laboratory experiments furnish any confirmation or explanation of the apparently observed beginning of visible fog condensation in air far below normal saturation,[2] and its gradual growth with increasing vapor pressure into the ordinary, dense, atmospheric fog.

Long ago Lord Kelvin showed that a drop of pure water will evaporate in the presence of water vapor that is saturated with respect to a flat surface. This evaporation is due to the increased internal energy of the drop caused by the pressure of surface tension. The surface tension energy per unit area of a liquid surface is the same for flat and curved surfaces; but the tension of the curved surface around a drop of the liquid squeezes the drop and thus increases its internal energy. On drops of pure water of the ordinary sizes, owing to the changing curvature of the surface, the pressure due to surface tension increases as the radius of the drop diminishes. Since a drop of pure water will evaporate in a vapor just saturated, of course no drop can maintain its integrity unless the vapor has a degree of supersaturation precisely suited to the size of the drop. Any slight variation of the amount of moisture will make the drop either grow and fall as rain, or evaporate and disappear.

So there can be no gradual growth of fog from small vapor pressures. Any possible fog will appear suddenly when the appropriate supersaturation is reached, and it will necessarily be transitory. Practically, then, there can be no atmospheric fog of pure water droplets.

[1]A study of the summer fogs of Buzzards Bay, Vol. XXXI, p. 467.

[2]The terms "saturation" and "normal saturation" are used thruout in the sense of saturation for flat surfaces, or the degree of saturation in which the wet and dry bulbs of a sling psychrometer read alike. The terms "saturated" and "undersaturated" refer to this standard. The reasons for the distinction will appear.